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Our ref: TS 7640 EPC P

European Patent Application No. 04804628.8
Shell Internationale Research Maatschappij B.V.

Dear Sir or Madam

Please find our response to the Communication pursuant Art. 96(2) EPC (1973) in the above referred to case.

Amendments

We herewith submit a set of amended claims. Claim 1 has been amended, basis original claims 1 and 5. Claim 5 as originally filed has been cancelled without prejudice. Claims 6 to 14 have been renumbered accordingly. Furthermore, we submit an amended page 2 to replace page 2 presently on file, and a new page 2a, adding a discussion of D1.

For clarification, we refer to the amended set of claims and amended pages enclosed.

1. Novelty

Since claim 5 as originally filed was considered novel, amended claim 1 should be novel as well. Claims 2 to 13 are novel by virtue of their dependency on claim 1.

2. Inventive step

Inventive step in view of D2 (US-A-2003/0115857)

We consider D2, or more specifically the embodiment disclosed in Figures 3 and 4 and [0024]-[0026] as closest state of the art, since it relates to the same field (process for operating a combustion engine with exhaust gases), and since it is equally concerned with the provision of a solution to NOx abatement process.

Although both D1 and D3 have some features in common with the present invention, they are primarily concerned with the operation of a solid oxide fuel cell in an engine/fuel cell arrangement, and hence would not have formed a suitable starting point.

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The mentioned embodiment of D2 discloses a process for the catalytic exhaust gas after-treatment of engine combustion emissions by an NO_x storage catalyst which can be regenerated by feeding hydrogen to the exhaust gas upstream of the NO_x storage catalyst. This is achieved by operating an internal-combustion engine by a hydrocarbon fuel, such as gasoline or Diesel, which is also available to a reformer for producing a hydrogen-rich synthesis gas. The synthesis gas is then employed to drive a solid oxide fuel cell, as well as for the regeneration of a NO_x storage catalyst.

The present invention differs from that disclosed in D2 in that a fuel composition comprising a Fischer-Tropsch derived hydrocarbon stream for both the compression ignition engine, as well as the catalytic partial oxidation reformer. This has the effect that less sulphur oxides will be trapped in the NO_x abatement system, thereby improving performance of this system (see page 9, lines 14-19 of the present specification).

Accordingly, the objective problem in view of D2 can be formulated as to provide for a process for the operation of a combustion ignition engine with improved NO_x abatement performance.

D2 does not teach or suggest use of a specific fuel, more specifically the use of a Fischer-Tropsch diesel fuel for a compression ignition engine.

Accordingly, we consider the process according to claim 1 non-obvious in view of D2.

Inventive step in view of D2 and D1 and/or D3

D1 (US-A-2003/0168263) discloses] a hybrid electric power train having an engine configured to produce reformat to feed a solid oxide fuel cell (see [0009]). The line-up according to D1 further comprises a start-up reformer to generate reformat until the engine supplies the fuel gas blend for the solid oxide fuel cell ([0031]). D1 further discloses in [0055] a list of considerable length of possible fuels for this line up, including "Fischer Tropsch".

Since D1 is directed mainly at a hybrid electric power train, and since it is void of any further information on how to improve the performance of the NO_x abatement system through selection of engine and reformer fuel, there is no reason why a skilled person would have contemplated D1 when looking at a solution to the above problem.

However, even in the unlikely event that a skilled person would have done so, he or she would not have had any reason to select a Fischer-Tropsch fuel for use in a compression ignition engine on the basis of the teaching of D1.

D3, similar in its disclosure to D1, is fully silent about the use of a reformer to generate synthesis gas for the NO_x abatement system. Although D3 discloses that a solid oxide fuel cell could operate as a reformer, this is only true for methane or methanol as fuels in the experience of Applicant.

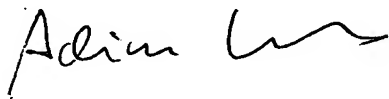
Yet further, D3 is void of information on Fischer-Tropsch derived fuels. We therefore submit that there is no reason or suggestion that would have led a skilled person to contemplate D3, or to combine the teaching of D3 with the process of D2 when trying to solve the above problem.

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To summarise, we are of the considered opinion that the process according to claim 1 is inventive over D2, and any combination thereof with D1 and/or D3. Claims 2 to 13 are inventive by virtue of their dependency on claim 1.

Yours faithfully
Shell International B.V.

A handwritten signature in black ink, appearing to read 'Adim' followed by a stylized flourish.

A. Krebs (GA17132)

Encls. Set of amended claims, amended page 2, new page 2a

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- hence there is frequently observed to be a "trade-off" between NO_x and particulate emission.

In order to reduce NO_x emissions of lean burn internal combustion engines, NO_x reducing exhaust gas treatment systems have been developed. These NO_x reducing systems typically comprise a NO_x reducing catalyst.

In US 5,412,946 for example, a NO_x reducing catalyst comprising Pt on zeolite have been described. Such a catalyst promote the reduction of NO_x to nitrogen in the presence of a reducing compound. It has been described in the art to use hydrocarbons, hydrogen or synthesis gas as reducing compound for this type NO_x reducing catalyst.

US-A-2003/0168263 discloses a hybrid electric power train having an engine configured to produce reformat to feed a solid oxide fuel cell. The line-up further comprises a start-up reformer to generate reformat until the engine supplies the fuel gas blend for the solid oxide fuel cell. The reformat is also directed to an exhaust system for regeneration of an NO_x abatement catalyst in the exhaust system.

NO_x reducing systems that comprise both a deNO_x catalyst and a NO_x sorbent are also known in the art. For example from US 5,874,057, US 5,473,887 and WO 01/34950. During lean operation, NO_x is absorbed from the exhaust gas; during richer operation, the sorbent is regenerated and the catalyst promotes reduction of NO_x to nitrogen. It is disclosed that the exhaust gas can periodically be made richer (less oxygen)

by adding fuel, hydrogen or synthesis gas to the lean exhaust gas.

5 An alternative method to reduce emissions of
compression ignition internal combustion engines is by
means of a process known in the art as fumigation. In a
fumigation process, a gaseous fuel is mixed with the
intake air of the engine prior to introducing the
air/gaseous fuel mixture into the engine cylinder. Both
diesel fuel and the air/gaseous fuel mixture are
10 introduced into the engine. Known gaseous fuels for
fumigation are for example natural gas, liquefied
petroleum gas (LPG), and hydrogen gas.

C L A I M S

1. A process for operating a compression ignition internal combustion engine in combination with a catalytic partial oxidation reformer and a NO_x abatement system as exhaust gas aftertreater, wherein:

5 (a) a mixture of a first fuel and air, wherein the first fuel comprises Fischer-Tropsch derived fuel, is introduced in the combustion chamber of the engine;

(b) exhaust gas is discharged from the engine and optionally partly recirculated to the combustion chamber of the engine;

10 (c) a second fuel and oxygen and/or steam are supplied to the catalytic partial oxidation reformer to produce synthesis gas, wherein the second fuel comprises Fischer-Tropsch derived fuel;

15 (d) at least part of the synthesis gas is supplied to:

(i) the exhaust gas aftertreater;

(ii) the combustion chamber of the engine; or to both; and

wherein the non-recirculated part of the exhaust gas and at least part of the synthesis gas are supplied to the NO_x abatement system.

20 2. A process according to claim 1, wherein the first fuel and the second fuel are the same fuel.

3. A process according to claim 1 or 2, wherein the first fuel and the second fuel comprise at least

25 10% (v/v) Fischer-Tropsch derived fuel, preferably at least 50% (v/v), more preferably at least 80% (v/v), even more preferably consist of Fischer-Tropsch derived fuel.

4. A process according to any one of the preceding claims, wherein the Fischer-Tropsch derived fuel is a gasoil.

5. A process according to any one of claims 1-4, wherein
5 the NO_x abatement system comprises a NO_x trap comprising a NO_x reducing catalyst and a NO_x sorbent.

6. A process according to claim 5, wherein the non-recirculated part of the exhaust gas is continuously supplied to the NO_x trap and the synthesis gas is
10 intermittently supplied to the NO_x trap.

7. A process according to claim 5, wherein the NO_x abatement system comprises two NO_x traps and wherein each trap is alternately supplied with the non-recirculated part of the exhaust gas and the synthesis gas such that
15 one trap is supplied with the exhaust gas and the other trap with the synthesis gas.

8. A process according to any one of claims 1-4, wherein the NO_x abatement system comprises a NO_x reducing catalyst without a NO_x sorbent and the non-recirculated
20 part of the exhaust gas and the synthesis gas are simultaneously and continuously supplied to the NO_x reducing catalyst.

9. A process according to any one of the preceding claims, wherein at least part of the synthesis gas is
25 supplied to the combustion chamber of the engine.

10. A process according to any one of the preceding claims, wherein at least part of the exhaust gas is recirculated to the combustion chamber of the engine.

11. A process according to claim 9, wherein the amount of
30 synthesis gas supplied to the combustion chamber of the engine is such that the volumetric ratio of 'synthesis

gas'-to-'first fuel' supplied to the combustion chamber is at most 25%, preferably at most 20%.

5 12. A process according to claim 9 and 10, wherein the amount of synthesis gas supplied to the combustion chamber and the amount of exhaust gas recirculated to the combustion chamber is such that the volumetric ratio of 'combined synthesis gas plus exhaust gas' to 'first fuel' supplied to the combustion chamber is at most 25%.

10 13. A process according to any one of the preceding claims, wherein part of the synthesis gas is supplied to a fuel cell to generate electricity, preferably a solid oxide fuel cell.